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THE AMERICAN METEOROLOGICAL JOURNAL.

A MONTHLY REVIEW OF METEOROLOGY.

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THE AMERICAN

METEOROLOGICAL JOURNAL.

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A METEOROLOGICAL BALLOON ASCENT AT BERLIN, OCT. 24, 1891.

A. LAWRENCE ROTCH.

THROUGH the kindness of Dr. Assmann, president of the Berlin Aeronautical Society, the writer was invited to take part in the fourth ascent of its balloon, the "M. W.", for the purpose of making meteorological observations in connection with simultaneous records obtained by a captive balloon, the "Meteor," at an altitude of about six hundred meters, and eye observations and automatic records near the surface of the ground.

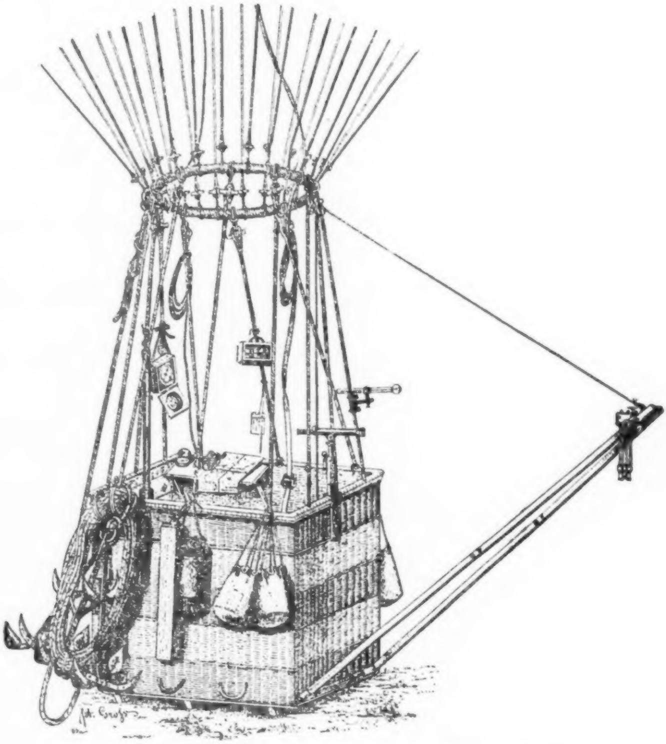
The captive balloon, "Meteor," which is owned by the Society, has a volume of one hundred and eighty-five cubic meters and can lift sixteen kilograms besides itself and eight hundred meters of wire cable, operated by a steam winch in a field near the Charlottenburg gas works. The aspiration meteorograph of Dr. Assmann is attached to the ring of the balloon by gimbals, so that it will always maintain a horizontal position. The meteorograph for balloon use has a continuous aspiration of air, in order to neutralize the effect of radiation, and a special device is applied to counteract the effect of shocks, which are unavoidable in a captive balloon, upon the recording pens. This latter end is accomplished by placing the pens on fine chains which are stretched horizontally over rollers, these pens being balanced by counterweights on the under portions of the chains, thus rendering them indifferent to shocks in any direction. The aspiration of air past the thermometer tube, which is a modification of that used in the Richard thermograph, a

circular tube being substituted for the usual Bourdon tube, is effected as in the Assmann aspiration psychrometer (described in this JOURNAL, Vol. VIII., No. 5), the ventilating fan being driven by a small dynamo-electric motor, fed from batteries carried by the balloon.

The meteorograph also contains a hair hygrometer, ventilated by the above-mentioned current, and an aneroid barometer, similar to that of Richard *frères*. The registration of the three elements — atmospheric pressure, temperature, and relative humidity of the air — is made on three drums, thirty centimeters in diameter, which turn about their horizontal axes once in five hours, so that one minute corresponds to one millimeter on the record sheets. The whole apparatus weighs only sixteen kilograms, of which the meteorograph itself, made mostly of aluminum, enters for less than nine kilograms. A similar meteorograph and an aspiration psychrometer are hung two meters above the ground in the field already mentioned.

The free balloon, "M. W.", has a capacity of one thousand two hundred cubic meters, and when filled with illuminating gas can lift two hundred and fifty kilograms besides its own weight of four hundred and fifty kilograms, permitting three persons and the following instrumental equipment to be carried. An aspiration psychrometer is hung from the apex of a triangular frame two meters outside the basket, to whose bottom the base of the frame is hinged. By means of a cord this frame can be swung in towards the basket, in order to wet the thermometer bulb and wind the clock movement driving the aspirator, which must be done each ten minutes. The thermometers are read through a small telescope fastened to the edge of the basket. A solar thermometer with a black bulb in vacuo is clamped to one of the ropes supporting the basket, so that its position can be changed to keep it in sunshine. As a mercurial barometer is both fragile and difficult to read in a balloon, it has here been replaced by an aneroid which had been compared with a standard instrument at low pressures. A small and light barograph made by Richard *frères*, contained in an aluminum case and reading up to five thousand meters, belonging to the writer, has proved itself a reliable instrument both in the ascent of Oct. 24 and previously in a pneumatic cabinet under pressures corresponding to various altitudes. A similar instru

ment has since been presented by the writer to the Society in recognition of the courtesy afforded him. Before the balloon touches the ground the instruments are packed in padded boxes



BASKET OF THE BALLOON "M. W.," WITH ASSMANN'S APPARATUS.

and hoisted into the net under the gas-bag, where they are least liable to injury by the shock of landing.

The writer's main object in making the ascent was to compare the sling and aspiration thermometers, as the latter had been used as a standard of comparison for the Richard thermograph during balloon ascents from Paris in November, 1889, when the latter instrument was found to give much too high temperatures (see this JOURNAL, Vol. VIII., No. 5).

The *personnel* in the fourth ascent of the "M. W." was

this: aeronaut, 1st Lieut. Gross, of the Army Balloon Corps, who, being an experienced scientific and military aeronaut, has been of great service to the society, of which he is librarian; observers, Dr. Berson, of the Prussian Meteorological Institute, and the writer. The following scheme of observations was prepared by Dr. Assmann, who remained in Charlottenburg with Dr. Kremser, a secretary of the society, to make readings of the aspiration psychrometer and to superintend the meteorographs there and attached to the "Meteor": The eye observations near the ground and in the "M. W." were intended to be made at least every five minutes, the times of the latter being obtained from a watch (which agreed with that of the lower observer) hung near the telescope. Ten seconds before each observation in the "M. W." a signal was given by Dr. Berson and the time announced, when Lieut. Gross read the aneroid barometer. After five seconds, during which time Dr. Berson determined through the telescope the whole degrees shown by the psychrometer and Lieut. Gross watched any changes of the aneroid, a second signal was given, when tenths of degrees were read by Dr. Berson; at the even minute, at another signal, a look at the instruments, before recording their readings, confirmed the fact as to whether any changes had occurred. The writer observed, as near as possible synchronously, a sling psychrometer whirled outside the basket, though on account of the time required to lower the temperature of the wet-bulb after moistening, it was not always practicable to make readings simultaneously with Dr. Berson. The writer also noted the temperature of the solar thermometer and the brilliancy of the sunshine, as well as the kind and amount of the clouds above and below the balloon.

The start was made at 10.36 on the morning of Oct. 24, with sixty-five kilograms of ballast and the *personnel* and equipment already described. Almost at the same time two pilot balloons and the "Meteor" were sent up. The weather was hazy and apparently calm, but the "M. W." slowly drifted west, then rising higher veered to northwest, until on reaching an altitude of eight hundred and fifty meters it turned northeast, and passing over Tegel and Bergfelde descended at Schmachtenhagen, near Oranienburg, at 1.41 P. M., after a voyage of 34.3 kilometers in three hours five minutes. The "Meteor" was

not lowered until 2.30 P. M. The greatest altitude attained by the "M. W." was one thousand two hundred meters at 1.20, and by the "Meteor" nearly seven hundred meters between 11 o'clock and noon, the mean height of the former being about one thousand, and of the latter six hundred meters.

The results of the observations at the three levels have been tabulated by Drs. Assmann and Berson and plotted graphically by Lieut. Gross. From them, it appears that the mean decrease of temperature between the ground and the "Meteor" (0 to 600 meters) was about 0.60° C. per 100 meters, the variations being 0.33° to 0.88°. In the stratum of air between the "Meteor" and the "M. W." (700 to 1,000 meters) the decrease was much slower during the morning, there being at first an increase, *e. g.*, at 11.08 A. M., the temperature at 693 meters was 10.0° C. and at 858 metres, 10.4°. In the afternoon the rate of decrease in the upper stratum became nearly the same as that which prevailed in the lower stratum during the morning. The relative humidity varied irregularly, but generally increased slightly during the morning hours up to seven hundred meters, and decreased higher up, the humidity at one thousand meters being from two to nine per cent less than that near the ground. In the afternoon a rapid decrease between the ground and the "Meteor" at an elevation of five hundred meters occurred, the humidity at the latter altitude being, in some cases, nine per cent less than that at the ground.

The weather conditions over Europe on the morning of Oct. 24 were as follows: The chief barometric depression, which was rapidly filling up, having a minimum pressure of seven hundred and forty millimeters, was central over Scandinavia, while one high-pressure area, with a maximum of seven hundred and sixty millimeters, was central over Italy, and another of the same intensity lay over Russia. A secondary depression, moving east, covered England. In Central Europe the pressure was nearly normal and uniformly distributed, and hence the winds were light. In Northern Germany the weather was partly cloudy or foggy, with calms or light southerly and southwesterly winds, while the temperature was above normal.

The deflection of the wind in a right-handed rotation, from east near the earth to southwest at an altitude of one thousand meters, as well as its low velocity, is what might have been

expected from the distribution of pressure and the shallow gradients shown on the synoptic chart above quoted. The average velocity of the balloon was 3.08 metres per second, and the velocity in different strata, as determined by the balloon's passage over certain points, was two meters per second from the east and southeast up to eight hundred meters' elevation, and three meters per second from the south and southwest between eight hundred and one thousand two hundred meters. The pilot balloons, which probably attained an altitude of two thousand or three thousand meters, followed nearly the same course as the "M. W.," but moved with a velocity of some fifteen meters per second. The cirrus clouds, which before the departure of the balloon were observed drifting slowly from the southwest, showed that the whole upper stratum of air, up to the cirrus level, had the same direction of motion.

The intensity of the solar radiation at the earth's surface and at one thousand meters above it was as 11.1 to 26.5, these being the maximum differences between the readings in degrees of the aspiration thermometers and the solar thermometers at 11.51 A. M., near the ground and in the balloon "M. W." respectively.

To a height of three hundred meters above Berlin the air was filled with haze, but above that the sky was clear except for some cirro-stratus clouds which at times obscured the sun. Soon after noon some small cumulus clouds appeared to form below the balloon at a height of about seven hundred meters above a large forest. The shadow of the balloon surrounded by a yellow diffraction fringe upon the ground and the dazzling reflection of the sun as a disk of molten gold in the river and ponds were interesting optical phenomena.

The most important result of the ascent, however, was furnished by the comparison between the aspiration and sling psychrometers, which confirmed the opinion of Dr. Assmann regarding the untrustworthiness of the latter. As a fact, the air temperatures obtained by this instrument, with rather intense radiation, were always higher than those given by the aspiration thermometer, the difference averaging about 2° C. and varying from 0.3°, with feeble radiation, to 3°. The relative humidities obtained with the aspiration psychrometer were generally from 0 to 9 per cent above those with the sling psychrometer, the

wet-bulb of the former being less depressed with respect to the dry-bulb than was the wet-bulb of the latter instrument. These results seem to demonstrate that the sling psychrometer, as used in a balloon, where it cannot be swung far away from the basket, and under intense insolation, gives values which are not only too high, but which do not follow the constantly changing temperature and humidity of the air. Undoubtedly, determinations made with the sling thermometer are much better than those generally given for balloons where the temperatures are obtained by thermometers hung inside or outside the basket. Thus the thermograph readings, mentioned on page 208, Vol. VIII., of this JOURNAL, as being from 5° to 8° above those of the sling thermometer must have been nearly 10° above the true air temperature.

The employment of balloons in the manner described, represents, the writer believes, the best existing method of determining the true temperature and humidity of the atmospheric ocean, when this is in a state of comparative rest, and under the able direction of Dr. Assmann very valuable data may be obtained as the result of further experiments.

IMPROVEMENT OF WEATHER FORECASTS.*

PROF. H. A. HAZEN.

THERE is no doubt that a scientific method of forecasting the weather is a great desideratum. After an experience of five years, it seems to me that nearly all our predictions are from symptoms, so to speak, or conditions that appear on the surface of our maps — we are not yet able to "read between the lines." The situation may be likened to the treatment of disease by symptoms purely. The physician may be able to alleviate suffering by treating outside appearances, but he can effect no cure unless he goes back of these and ascertains the cause of the trouble and eliminates that from the system. In weather forecasting, if only we knew, or could ascertain, the cause of rain, hot waves, cold waves, highs, lows, etc., we would be in a position to treat the subject from a scientific standpoint

* Published by permission of the Chief of the Weather Bureau.

and to obtain a view of the causes which have led to the existing conditions on any weather map, and after that we could intelligently study modifying influences. In other words, aside from observations of atmospheric electricity and of the meteorologic elements at some height in the atmosphere, the most promising line of research seems to be in definitely determining the causes of these phenomena, about which we are almost totally ignorant.

Hot and Cold Waves. — In the absence of observations in the free atmosphere, those on mountain tops will answer nearly the same purpose in most cases. The diurnal range of temperature would be so much affected by the mountain top, and air currents up the sides, that it could not be depended upon for giving the range of temperature in the free air. It is far otherwise, however, with the greater fluctuations of temperature which accompany our hot and cold waves and which are but slightly affected by the presence of the mountain, if at all. Much has been written on the relations existing between temperature changes at the base and the summit of mountains, and a correct determination of these relations would be of the greatest value to meteorology. Care must be taken in a study of this kind that we are not deceived by purely local conditions at the base of the mountain which would have no effect at the summit; for example, the flow of cool air down the side of the mountain, the abnormal heat in the air on the leeward side, etc. Such conditions, however, can only slightly modify or mask the much more prominent fluctuations in the larger temperature waves.

At first sight, the diurnal range of temperature presents an obstacle to the use of readings oftener than once in twenty-four hours, but it is very essential that we devise some means of eliminating this, if we would closely follow the time of the crests and hollows of these temperature waves. If this range were approximately constant from day to day, it could be disposed of easily by adding a certain small quantity to the morning observations, and subtracting a small amount from that during the hotter part of the day, leaving the night observation untouched. For example, if the three readings were 20°, 35° and 29° for the mean of a month's observations at morning, noon, and night, we would need to add 9° to each observation in the morning and subtract 6° from each afternoon reading, in order to eliminate the

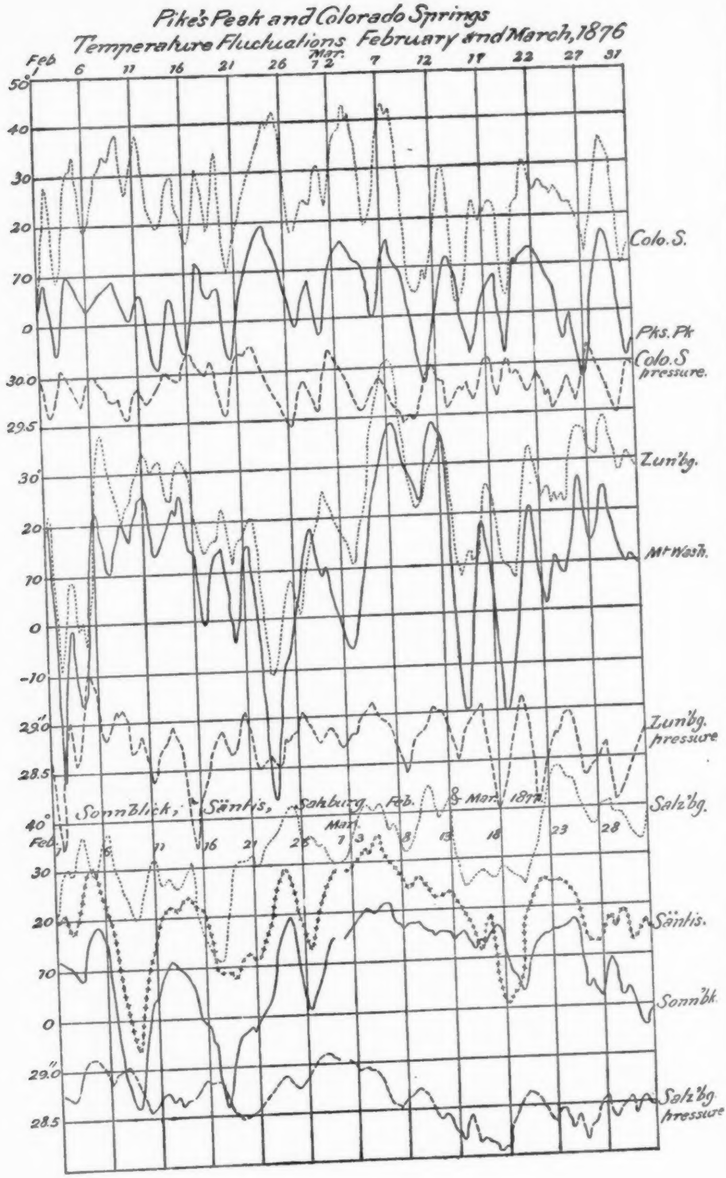
diurnal range. The principal difficulty in this method lies in an over compensation in the afternoon readings when there are clouds.

There is another method which obviates all difficulty from this source, and has proved perfectly satisfactory. This method is to strike successive means of the three observations. I have applied this method to the observations at Pike's Peak (14,134 feet) and Colorado Springs (5,950 feet); at Mt. Washington (6,279 feet) and Lunenburg (1,100 feet); also at Sonnblick (10,170 feet) and Salzburg (1,434 feet) in Austria. In the last case I have added Säntis (8,202 feet), which is 165 miles west of Sonnblick in Switzerland. The temperature fluctuations at base and summit of these mountains, for two months each, are given in the accompanying plates. In each set the full black curve is that for the summit, and the dotted at the base. In Set 3 the curve with crosses is for Säntis. The broken curve in each set represents the pressure at the base.

A comparison between the full and dotted black curves shows a remarkable coincidence; in fact, the crests and hollows of the summit curve are practically identical with those at the base. This identity is brought out more closely at Mt. Washington than at any other station, as was to be expected, since here we have more highs and lows passing the station.

At Pike's Peak the amplitude of the oscillations is nearly the same at the summit as at the base, but at the other stations the summit has the greater amplitude. A comparison of like curves for about fifteen years at the mountain stations in this country has shown that this is a universal law, namely, the temperature fluctuation is the same at the earth and at heights of three miles or more above the earth. This law holds over the whole globe, and is perfectly established by thousands of cases. In the foreign curves the very interesting fact is brought out that the fluctuations at the mountain stations, which are one hundred and sixty-five miles apart, are much closer together than are the curves at the summit and the base of Sonnblick, which are only about thirty miles apart.

Temperature Changes earlier at the Summit. — The Mt. Washington curves show the very significant fact that these crests and hollows generally occur at the summit from eight to sixteen hours earlier than at the base. This may be a very important



Pike's Peak and Colorado Springs
Temperature Fluctuations February and March, 1876
Colo. S.
Pks. Pk
Colo. S pressure.
Zun'bg.
Mt Wash.
Zun'bg. pressure
Salz'bg.
Sonnblick, Säntis, Salzburg. Feb. & Mar. 1877.
Säntis.
Sonn'bk.
Salz'bg. pressure

consideration in enabling us to determine the true causes of these waves. Some have thought that the fluctuation or wave must necessarily reach the summit first, because the velocity of the current at that point is two or three times as great as at the base. A little thought will show, however, that this principle when carried out fully will inevitably break up the continuity of the whole wave, for, if the top is borne along twice as fast as the bottom, it will require but a few hours to break the wave in two, and destroy it.

Comparison of Pressure and Temperature Curves. — On comparing the crests and hollows of the base-pressure curves with the hollows and crests of the summit-temperature curves we find that these phases are in most cases exactly opposite. Also, in nearly every case the temperature change precedes by several hours the pressure change. We may conclude from this, *that the passage of a storm at the earth's surface is concomitant with the occurrence of a warm wave up to heights of at least three miles in the atmosphere.* The contrary effect occurs on the passage of a high area at the base.

The Cause of Highs and Lows. — There is no question of such paramount importance in meteorology as this. May we not be helped to determine this by a study of these cold and hot waves?

First. These waves are not due to a transportation or movement of masses of cold and hot air. I presume this proposition will be very strongly combatted. The best proof, perhaps, is in the fact that air currents have a very variable or gradually increasing velocity as we rise in the atmosphere. At Mt. Washington during a hot wave the velocity of the current is often four times as great as at the base. It is very evident that a mass of air moving or starting to move in these currents would be very quickly broken up and dissipated.

Second. The direction of the upper currents which move at the velocity of the cold or hot wave is very different from that of the wave, — often the two are at right angles.

Third. These cold waves are not due to direct radiation of heat from the atmosphere. All agree that this would be exceedingly slight.

Fourth. They are not due to radiation from the ground. This is clearly shown by the fact that the wave extends to such

an enormous height, and also by the fact that it reaches the summit before it does the base.

Fifth. The cold wave as we find it on our maps is due to a settling, or an action of cold from above downward. It seems to me this is a most important principle, and its amplification will be of the greatest value in forecasting such conditions.

It is impossible, at present, to state the cause of these hot and cold waves, but I think there is one fact which may point to the proper line of study.

Moisture in the Air. — A long series of careful hourly and often more frequent observations on the moisture in the air has shown this to be the most constant element in meteorology. The moisture contents (absolute humidity) of the air are not appreciably affected by the sun's heat, by evaporation due to this heat, by the wind, unless blowing directly from a region where rain is falling, by clouds, or by any other commonly recognized element. Two illustrations are given of fluctuations in temperature and grains of moisture per cubic feet at Washington, D. C., in the accompanying tables.

TEMPERATURE AND ABSOLUTE HUMIDITY (GRAINS PER CUBIC FOOT), WASHINGTON, D. C.

Aug. 8, 1892.

Time.	Temp.	Ab. H.	Rel. H.	Time.	Temp.	Ab. H.	Rel. H.	Time.	Temp.	Ab. H.	Rel. H.
5.53	70.3	7.99	98	12.4	85.0	8.25	63	18.23	86.3	8.25	60
5.54	70.7	7.99	95	.6	83.3	7.99	66	.49	86.0	8.12	62
6.3	70.1	7.99	98	.7	84.0	7.99	64	.52	83.9	8.52	67
6.7	70.0	7.99	100	.8	84.0	8.12	64	.55	85.2	8.38	64
.30	70.3	7.99	100	.9	84.1	8.25	66	19.4	84.0	8.52	68
7.1	72.0	8.25	95	13.12	85.0	7.99	61	.7	85.4	8.52	64
.27	72.9	8.52	95	.13	84.8	7.99	61	.9	85.1	8.52	65
8.00	74.5	8.38	88	.27	85.0	7.87	60	.11	84.3	8.66	67
.58	77.4	8.12	80	14.00	86.3	7.99	59	.22	83.4	8.66	69
9.3	79.0	8.38	78	.27	87.0	7.99	57	.28	83.2	8.66	71
9.9	79.2	7.99	74	.28	86.4	7.99	58	20.3	83.8	8.80	69
.17	78.1	7.87	76	15.19	88.0	7.74	53	.5	82.4	8.80	73
.26	79.9	7.99	72	.51	86.2	8.25	60	.8	83.1	8.80	73
.54	80.8	7.99	69	16.7	87.0	8.25	58	21.42	78.8	9.08	85
10.18	81.3	8.12	70	.40	87.6	8.12	57	22.12	78.5	9.52	89
.38	82.0	8.25	69	.59	87.2	8.12	58	.14	79.9	9.08	83
.42	81.0	8.12	70	18.3	86.6	8.25	60	2.33	76.9	9.08	89
.46	82.7	8.25	68	.6	86.2	8.38	61	.38	77.2	8.66	86
11.14	83.5	8.25	67	.15	86.1	8.38	61	.41	76.6	8.80	88
.30	84.3	8.25	65	.20	86.0	8.38	61	5.17	73.3	8.38	94
.59	85.8	8.38	62					7.23	77.4	8.12	81

Aug. 6, 1892.

Time.	Temp.	Ab. H.	Rel. H.	Time.	Temp.	Ab. H.	Rel. H.	Time.	Temp.	Ab. H.	Rel. H.
22.37	71.7	6.58	77	11.40	79.0	7.74	71	14.00	84.7	5.57	42
6.10	67.0	6.15	85	.41	78.8	7.74	72	.30	85.3	6.15	47
.12	67.4	6.36	87	.44	79.7	7.74	70	.32	86.0	6.58	48
.17	67.1	6.15	85	.46	79.8	7.74	70	.48	85.8	6.15	45
.27	67.8	6.15	83	12.10	81.6	6.69	57	15.26	84.8	6.15	47
7.2	71.0	6.36	77	.12	82.8	6.58	52	16.16	83.0	6.58	52
.32	72.7	6.36	71	.16	82.0	6.36	53	.17	83.0	6.58	53
8.54	74.0	6.36	70	.18	81.8	6.58	55	.47	84.0	6.80	53
.57	74.8	6.58	70	13.33	84.3	4.86	38	.48	83.4	6.80	54
9.5	75.3	6.80	72	.35	84.3	4.54	35	17.3	84.1	7.02	54
.47	76.0	7.25	74	.38	84.2	4.70	36	.4	83.3	6.80	54
.53	75.2	7.25	76	.40	85.8	4.70	35	18.11	81.0	7.02	60
.55	76.2	7.49	76	.41	85.4	5.20	38	.12	82.0	7.49	62
10.13	76.8	7.25	73	.44	85.4	5.47	40	19.11	79.0	7.37	69
.36	76.8	7.49	74	.46	85.0	5.38	39	.13	79.0	7.49	70
.37	76.3	7.25	74	.50	85.0	5.57	41	.20	78.4	7.61	71
.51	78.0	7.49	73	.51	84.8	5.20	39	.36	77.3	7.49	73
.59	78.0	7.74	75	.52	85.0	5.38	40	.38	78.9	7.25	68
11.00	78.0	7.49	73	.53	85.0	5.57	41	20.00	78.2	7.61	74
.31	79.2	7.74	71	.54	84.8	5.38	40	.13	77.0	7.25	73
								21.44	75.2	7.49	78
								5.3	67.7	6.15	83

On Aug. 8 the temperature of the air rose steadily up to 17^{h}.00, when it was nearly 18° higher than in the morning. The absolute humidity remained practically without change from 6.00 to 18.00. The slight differences are entirely due to errors of observation. After 16.00 there was a slight increase until 22.00, when the amount of moisture began diminishing, possibly from a copious deposition of dew.

On Aug. 6 the observations are full of interest, from the fact that without rain the amount of moisture increased from 6.00, when it was 6.15 grains per cubic foot, until 11.44, when it was 7.74.

From the latter point there was a most extraordinary drop in the moisture, reaching 4.54 grains at 13.35. This is one of the sharpest falls in this element that has been noted in many years, and appears to be very difficult of explanation. From 13.35 the moisture gradually increased till it recovered its former value at 19.20.

There is a remarkable increase of moisture in the front of a storm, and this is independent of any known element. This increase occurs long before any fall of rain, and is not dependent

on that. In the case just cited, Aug. 6, there was no rain about. There is a corresponding remarkable decrease of moisture in front of high areas. This decrease is not due to the saturation and consequent condensation of moisture by cooling, since the air is never saturated under these circumstances; in fact, the relative humidity diminishes very rapidly with this fall in temperature. These changes in moisture contents take place at mountain summits as well as at the base, and without doubt they occur earlier above than below, hence it is plain that heat evaporation of moisture from the earth or its waters can have little or nothing to do with these changes.

Changes in Moisture Contents over Large Areas.—If we take out the change in moisture in twenty-four hours for a large number of stations and plot them upon a map, we shall find some quite remarkable changes. I give two tables containing such changes in the moisture at a large number of stations on Feb. 24, 1891 and Nov. 30, 1891. On Feb. 24 there was a diminution in the moisture contents of the air at Omaha of 2.37 grains and a rise of 2.84 at Louisville, or a total change of over 5.5 grains in twenty-four hours at these stations not very far apart. Ordinarily the amount of moisture in the air is very constant, and it is impossible at present to explain such great changes.

CHANGES IN TWENTY-FOUR HOURS IN THE MOISTURE OF THE AIR (GRAINS PER CUBIC FOOT).

Feb. 24, 1891.

— Changes. Station.	Amount.	+ Changes. Station.	Amount.
Moorhead	.32 gr.	Milwaukee	1.80 gr.
St. Paul	.90	Grand Haven	1.34
La Crosse	.94	Detroit	1.58
Huron	.45	Toledo	1.34
Yankton	1.64	Cleveland	1.48
Dubuque	1.19	Erie	1.72
Des Moines	1.47	Buffalo	.75
Keokuk	.90	Pittsburg	1.26
Omaha	2.37	Columbus	1.73
North Platte	1.52	Indianapolis	2.27
Concordia	1.39	Cincinnati	1.80
Kansas City	2.72	Springfield, Ill.	1.91
Dodge City	1.36	St. Louis	1.52
Fort Sill	1.26	Louisville	2.84
Fort Smith	.28	Cairo	2.56
		Nashville	2.57
		Chattanooga	2.41
		Atlanta	2.30

Nov. 30, 1891.

— Changes. *Station.*	*Amount.*	+ Changes. *Station.*	*Amount.*
Parkersburg	.19 gr.	St. Paul	.40 gr.
Washington	.70	Green Bay	.26
Lynchburg	.82	La Crosse	.38
Knoxville	.35	Yankton	.16
Charlotte	.97	Milwaukee	.04
Kitty Hawk	1.54	Grand Haven	.09
Wilmington	4.29	Des Moines	.90
Atlanta	.67	Davenport	.60
Augusta	2.22	Chicago	.05
Charleston	3.49	Omaha	.65
Meridian	.30	Indianapolis	.23
Montgomery	.58	St. Louis	.28
Savannah	2.71	Louisville	.35
Jacksonville	4.22	Kansas City	1.30
Mobile	.58	Concordia	.90
New Orleans	1.36	Dodge City	.63
Tampa	3.94	Wichita	.46
Titusville	2.56	Cairo	.19
Jupiter	3.94	Oklahoma	.30
		Shreveport	.26

I feel myself that a study of the moisture conditions at various heights in the atmosphere, and above all, a determination of the cause of these fluctuations of the moisture contents of the air would be of the greatest benefit to forecasting and to meteorology. I am also satisfied that a study of our maps of moisture will reveal a good many valuable facts, though perhaps there are other ways of investigating the question that will give better results. I think it probable that the greatest hope in the line of scientific predictions is in the observation of atmospheric electricity.

Aug. 5, 1892.

PAPERS FROM THE PHYSICAL GEOGRAPHY LABORATORY OF HARVARD COLLEGE.

No. 8.—THE STORMS OF INDIA.

SIDNEY M. BALLOU.

THE METEOROLOGICAL SERVICE OF INDIA.

FOR more than half a century the meteorologists of India have published data relating to the storms of that country. The fund of scientific knowledge thus collected rivals in completeness that concerning the storms of Europe and North America. Its especial value, however, lies in the fact that it includes the only thorough study of the meteorology of a tropical country that has yet been made. In its special department it stands alone.

The publications here referred to began in 1839 with Piddington's "First Memoir on the Law of Storms." At that time the conflict between the radial and the circular theories of storms was at its height. Appreciating the need of reliable data, Piddington collected all the information obtainable from the logs of vessels that had been involved in a certain storm in the Bay of Bengal, and of all vessels in the bay at that time. A careful tabulation and comparison of these observations showed not only the cyclonic motion of the winds, but also the extent and movement of the storm.

This first memoir was followed by others of the same kind, until the series reached the number of twenty-five, extending through a period of nineteen years. The result was a collection of valuable data sufficient to determine all the characteristic features of the Indian storms; and except for Piddington's adherence to the theory that the winds blew in complete circles, his generalizations were always accurate.

Besides this, the system was effective in arousing the attention of seamen to the importance of keeping accurate logs. At first, records were difficult to obtain, and the significant observa-

tions that were needed were often lacking. Captains would not answer letters of inquiry, or replied that they "had no time to attend to such trifles." As the successive publications appeared, however, masters of vessels learned that their routine observations were of importance, and if forwarded to Calcutta, a full return would be made to them in the form of practical sailing rules. As accuracy was always insisted upon, the quality of material steadily increased, until the system reached a high grade of efficiency.

After ten years of observations of this kind, Piddington published his "Sailors' Horn Book," which presented, in a popular and comprehensive way, the knowledge of storms required by sailors. The book took its title from two accompanying cards of transparent horn, which were designed to determine the bearing of the cyclonic centre, from the direction of the wind.

Piddington was followed by others, notably by Wilson, of Calcutta, and Chambers, of Bombay; and finally in 1875, the present Meteorological Department of the Government of India was established. It has produced many excellent volumes of records and memoirs under the leadership of Blanford, the first Director, and Eliot, his successor now in office. Besides a large quantity of meteorological statistics of high order and daily weather maps, this department has published several series of valuable works. First of these are the "Indian Meteorological Memoirs." These, each written by a single member of the department, give the life history of all the more severe storms, or deal with the rainfall, wind velocities, or other meteorological features of different districts. Another series, the "Cyclone Memoirs," treats exclusively of the storms in the Bay of Bengal and the Arabian Sea. Lastly there are a number of general works, each of which presents the results of the investigations in a compact, popular form. The principal works of this kind are Blanford's "Meteorologists' Vade Mecum" and "Climates and Weather of India"; Eliot's "Handbook of Cyclonic Storms in the Bay of Bengal"; and a Meteorological Atlas.

THE METEOROLOGICAL FEATURES OF INDIA.

Mr. Blanford uses the word *climates* in the plural in the title of one of his books to emphasize the fact that in this respect the different parts of India exhibit very great diversity. "North-

ern or extra-tropical India alone," he says,* "in its most easterly and mostly westerly provinces, in Assam on the one hand and in Sind on the other, presents us with the greatest possible contrast of dampness and dryness, a contrast greater than that of the British Isles and Egypt; and when, further, we compare the most northerly province, the Punjab, with the most southerly, such as Travancore or Tenasserim, we have, in the former, a continental climate of the most pronounced character,— extreme summer heat alternating with winter cold that sometimes sinks to the freezing point,— and, in the latter, that almost unvarying warmth, in conjunction with a uniformly moist atmosphere, that is especially characteristic of the shores of a tropical sea."

To understand this diversity of climates we may best consider the place which India occupies in respect to the general terrestrial circulation of the winds. The doldrums, or the belt of equatorial low pressure, which in most longitudes migrates a short distance north and south of the equator, is here replaced in summer by an area of low pressure over the northern part of India. The cause of this is the excessive heat of the land as the sun comes north, which is well shown by the fact that, as the summer season advances, the northward migration of the belt is gradual until the temperature of the land becomes greater than that of the doldrums; then the equatorial low pressure weakens and disappears, while a new area of low pressure forms over the northern part of the peninsula.

These different positions of the doldrums in summer and in winter are what give India the changes of winds known as the monsoons. From October to April, when the low pressure is to the south, the winds are prevailingly northeast. Then as the doldrums move northward they are followed by the southeast trade wind, which turns around to a southwest wind on crossing the equator; and as the pressure falls over northern India, this wind flows toward the low area, forming the summer monsoon.

The summer monsoon, however, is so much stronger on the land than the winter monsoon, that it is usually called "the monsoon," as though it were the only one. In the northern part of the country, in fact, the winter season is marked, not by a steady wind, but by calms, interrupted only by light zephyrs.†

* Climates and Weather of India: London, 1889, 95.

† Climates and Weather of India, 37.

These are anticyclonic conditions, and mark a complete reversal from the low pressure of summer. The reversal is occasioned by the fact that when the doldrums move south of the equator in winter, the sub-tropical belt of high pressure that encircles the earth at about latitude 30° also shifts to the south, and overlaps the northern part of India.

Nor is India subjected alone to the diversity of tropical conditions. In December, when the high pressure belt is at its southernmost limit, the northwestern provinces are left in the belt of westerly winds characteristic of the temperate zones. This is the season of the winter rains, which are cyclonic depressions of little intensity, but not easily broken by hills, travelling, unlike all other Indian storms, eastward, and followed by cold waves, nearly like the storms of North America and Europe, although of less intensity. Here, then, is a region in latitude 20° to 25° N., whose normal wind is the northeast trade; and yet at certain times of the year it is visited by the prolongation of the southeast trade from the southern hemisphere, and at others by the overlapping margin of the prevailing westerly winds of the temperate zone in the northern hemisphere. No other part of the world shows so singular a variety of atmospheric conditions.

THE SEASONS OF INDIA.

From these meteorological features follows the division of the Indian year into three seasons. The cold season begins with the setting in of the winter monsoon, in the latter part of September or in October. The weather is clear and settled until near the end of December, when the winter rains occur in the north. In January the temperature begins to rise, February is a spring month, and in March the hot season has fairly begun.

During March, April, and May the heat is intense and the dryness oppressive. On the northern plains the maximum thermometer averages about 102°, with recorded readings up to 121°. Europeans must take their exercise before sunrise or after sunset, for in the daytime the heat is too intense for them to venture out. All vegetation is dried up, and the country is parched and scorched.

In the latter part of June come the welcome summer monsoon

and the rains. The temperature falls to an endurable point and vegetation revives. These rains last from June to September.

The Meteorological Department has exceptional advantages for the study of these great diversities of climate. Government stations are numerous upon the land, while the two adjoining seas are constantly crossed by vessels from Europe and Australia. Cyclonic storms have been studied to especial advantage, for as all storms in the Bay of Bengal seem to originate in the bay itself, the numerous observations give the history of each storm from its very beginning.

THE THREE CLASSES OF CYCLONIC STORMS.

India has three distinct classes of storms. First are the cyclones that occur just at the changes of the monsoons, in May or October. These are known as the cyclones of the transition period. Second are the storms of the summer rains, which occur from June to September. Third are the winter rains of the northern provinces. It is proposed to give a brief description of each of these three classes of storms, and to discuss the causes of their formation.

As is well known, there are two antagonistic theories of cyclonic generation held at present. The first, suggested by Espy, and elaborated by Ferrel, is that the motive force of a cyclone is due, first to a local excess of temperature or aqueous vapor, which causes the initial indraught of winds, and afterwards to the latent heat liberated by the condensation of moisture into rain. This is usually called the convection or condensation theory.

The second theory is that advocated by Dr. Hann. Recent high level observations in Europe have led Dr. Hann to the conclusion that there does not exist in the interior of cyclones an excess of temperature sufficient to account for their circulation. Therefore, while not disparaging the effect of condensation as an aid to the cyclone's existence, he looks to the general circulation of the winds as the primary driving force. Such cyclones may be called dynamical.

It is not proposed to discuss the merits of these two theories. It is sufficient to say that Dr. Hann's observations, together with the greater frequency of cyclones in winter, and their origin

in places unfavorable to convectional action, have led many to the conclusion that the cyclones of the temperate zone must be accounted for upon the dynamical theory, and this paper will treat the subject from that position.

THE CYCLONES OF THE TRANSITION PERIOD.

The cyclones of the transition period originate in the Bay of Bengal. The circumstances of their origin are described as follows * :—

"The history of all cyclones in the bay shows that they are invariably preceded for longer or shorter periods by unsettled squally weather, and that during this period the air over a considerable portion of the bay is gradually given a rapid rotary motion about a definite centre. First of all, the squalls are comparatively light, and are separated by longish intervals of fine weather, and light variable or steady winds, according to the time of year. The area of unsettled and squally weather also extends in all directions. If the unsettled weather advances beyond this stage (which it does not necessarily do) it is shown most clearly by the wind directions over the area of the squalls. The winds always settle down into . . . the cyclonic winds of indraught to a central area of low barometer and heavy rain. As soon as the wind directions indicate that a definite centre of wind convergence has been formed in the bay, it is also found that the centre never remains in the same position for any considerable interval of time, but that it moves or advances in some direction between northeast and west."

When once formed these cyclones of the transition period are the fiercest storms of the tropical seas. Near their centre the winds blow with hurricane violence. Ships exposed to their full force are stripped of every inch of canvas. Boats lashed to the davits are sometimes torn from their fastenings and blown completely over the vessel. In fact, as often described by the captains, "everything the wind can reach is blown to pieces." The sea is perilously high, burying the vessel in foam; and the stoutest ships, when caught near the centre, can only scud under bare poles before the wind and sea.

At the centre of these storms, however, occurs the clear space known as the "eye of the storm." Across an area of ten or

* Eliot. Handbook of Cyclonic Storms. 89.

fifteen miles in diameter, within the circle of the most violent winds, there is an almost absolute calm, with clearing weather or blue sky. Within this area, however, the sea is still precipitous and dangerous.

These cyclones are formed in the open bay and attain a great intensity before reaching the coast of India. They are usually accompanied by a storm wave, the water being raised several feet by the winds and under the diminished pressure in the centre. Consequently, if they strike the low Indian coast at high tide, they frequently inundate large areas of the country. The Ganges, too, its mouth blocked by the high water and the fierce southerly winds, sometimes overflows and adds to the general destruction of life and property.

After these cyclones have reached the land, however, they are, in spite of their great violence, of short duration. The first range of hills in their path causes their complete disintegration. In a day or two the cyclone is reduced from a vortex of two or almost three inches below the normal pressure, to a scarcely noticeable barometric depression. "Such was the case, for instance, with the cyclone which, on the 1st of November, 1826, passed over Backergunge in Eastern Bengal, submerging the large islands at the mouth of the Megna, and sweeping some 100,000 human beings to destruction; but was dispersed and annihilated on meeting the Tipperah hills, which are not more than about 2000 feet high."*

The ease with which these storms are broken up is usually taken as proof that they are of no great height, but are confined chiefly to the lower layers of the atmosphere. Further evidence upon this point is given as follows†:—

"These storms, when viewed from a distance outside the storm area, appear as a comparatively low bank of clouds, and give evident signs of extending upwards to no great elevation. For a convincing proof of this it is only necessary to read Master Pilot Mr. Elson's account of the False Point Cyclone of September, 1885, as viewed by him from the Sandheads (*vide* Cyclone Handbook, page 171)."

The account referred to is as follows:—

* Blanford: Climates and Weather of India, 86.

† Eliot: Cycl. Mem., III, 272.

"The sky was overcast with towering cumulus which had overspreading pallium, from which occasionally rain fell here and there and which showed a stillness in the upper air strata. . . . So that, on the whole, the onset of this storm was much the same, both 'alow and aloft,' as was that which proved so very disastrous at False Point three years ago, and I have no doubt had we remained at anchor I should have seen the same towering clouds above the thin stratum of turmoil below, as I observed was the case in the former storm at the hour when it was blowing a hurricane at False Point, only 90 miles away. In fact there were some indications of this breeze being confined only to a thin surface sheet such as I saw on the former occasion."

There can be little doubt that these transition cyclones are convectional in origin. Mr. Blanford, in his paper upon "The Genesis of Tropical Cyclones*" brings forth a number of reasons in support of this view. In the first place the cyclones are formed only over the surface of the Bay of Bengal, while storms generated by the general circulation can scarcely be imagined to be subjected to this restriction. Second, the weather conditions connected with their origin show an increasing convection, with rain, until the cyclone is formed. Third, the storm remains stationary until formed; then, as the motion is communicated to the upper atmosphere, it moves in the direction of the upper current. Fourth, the small height and easy dispersion by hills indicate that the motive power is from the condensation of rain. Lastly, the temperature tests applied by Dr. Hann to the cyclones of Europe show that in these cyclones there is an accelerating force due to an excess of temperature.

(*To be continued.*)

* Nature, XLIII., Nov. 27, 1890, 81.

THE ETHER AND ITS RELATION TO THE AURORA.

EDWARD A. BEALS, OBSERVER, WEATHER BUREAU.

AS the maximum number of auroras, in consequence of their well-known correlation with frequency of sun spots, will probably occur during the coming year, it might be of interest to note a few facts regarding our knowledge of them in view of recent discoveries in terrestrial magnetism and the known properties of the ether, which the following extract, published in the January number of the AMERICAN METEOROLOGICAL JOURNAL, brought to mind as illustrating the vagueness regarding these phenomena now existing in the minds of many. The extract above referred to is as follows: —

"The orbits of heavenly bodies such as Encke's comet, Jupiter's satellites, etc., are subject to changes only to be accounted for by the action of some resisting medium, and it would be very satisfactory if it could be proved by spectrum analysis, for instance, that the aurora occurs in a medium different from our atmosphere, — not merely a medium for the propagation of light, which we call ether, but a gaseous substance, capable of considerable resistance."

The changes that take place in the orbit of Encke's comet, which Encke's investigations led him to infer were caused by the presence of a resisting medium, are, owing to the researches of Dr. Von Asten, — who ascertained that it is only in certain revolutions that an effect of this nature can be suspected, — generally believed to be caused by something else rather than by the presence of a resisting medium.

Regarding the irregularities occurring in the orbits of Jupiter's satellites, the cause is due to the time difference on account of Jupiter's variations of distance from the earth, which was proven beyond doubt by Bradley's discovery of aberration, as long ago as 1728.

That the interplanetary and interstellar spaces are occupied by a medium which has a finite density and possesses elasticity and is capable of transmitting energy can no longer be doubted. This medium is called ether, and its existence has been considered as far back as Plato, who described it as "a matter purer

and lighter than air, which, being diffused throughout space, it would be impossible to ascertain if it had weight."

Sir Isaac Newton came to the conclusion that there must be some medium different from ordinary matter that was concerned in *all kinds of phenomena*, but did not publish anything based on this theory because he was not able to give a satisfactory account of this medium.

Foucault's experiments in measuring the rate of propagation of light in water and air settled forever Newton's corpuscular theory of light and at the same time should have ended all opposition as to the existence of ether.

It has not been positively determined whether this medium has motion, and causes friction, nor the constitution of its atoms, but experiments regarding its motion have led to the belief that it has none, and as there is no evidence that any of the celestial bodies are retarded in their revolutions, there is good reason to believe the ether is frictionless; also that it is not made up of molecules similar to gases, because gases cannot transmit transverse vibrations, and it is probable that it has no weight, just as Plato stated over two thousand years ago.

Among the known properties of ether is its propagation of light, and the properties of this medium as deduced from the phenomena of light have been found to be precisely those required to explain electro-magnetic phenomena; it also propagates those radiations which do not produce a luminous impression on our eyes, for the phenomena of interference have been observed, and the wave lengths measured, in the case of radiations which can be detected only by their heating or chemical effects.

Faraday conjectured that the same medium which is concerned in the propagation of light might also be the agent in electro-magnetic phenomena, saying, "For it is not unlikely that, if there be an ether, it should have other uses than simply the conveyance of radiation."

A few years ago Hertz produced ether waves by electrical means, which could be reflected, refracted, and made to interfere the same as light waves, which showed that those produced by electro-magnetic means and those from heated bodies were similar, thus proving Faraday's conjecture to be a fact.

We now come to the phenomenon of the aurora, which has for

so long a time been studied, and, as Scott says, "The nature and origin of which is as little understood as atmospheric electricity."

Recent investigations in terrestrial magnetism, notably illustrated by Mr. Henry Wilde's magnetarium, and the newly discovered properties of ether, have made it much more comprehensible. Heretofore, about all we knew was that it was an electrical phenomenon, and was correlative with the mean diurnal variation of the magnetic needle and the frequency of black spots upon the sun's surface. Whether it was a vapory cloud electrically illuminated and of comparatively low altitude, as Scott inclines to, or rarely came down lower than forty miles from the earth's surface, as Loomis inferred, was to be conjectured, although Greeley's Arctic observations might be accepted as conclusive proof of its possible lower altitude. According to Dr. Willing's principle that "any number of coincidences between phenomena are of no value in showing a relationship, unless we can show *a priori* how such connections can exist," the correlations of the aurora with the mean diurnal variation of the magnetic needle and the frequency of black spots upon the sun's surface would until recently have had no scientific value.

The sun is electro-dynamic, as all hot celestial bodies are, and frequent changes are going on which are visible and called sun spots, and it has been shown that magnetic and light waves are propagated by ether with equal rapidity, and these magnetic waves are most active in the region of the earth's greatest magnetic susceptibility, viz., near the magnetic poles; consequently a change of potential in the sun would be felt here at the same moment of time that light would reach the earth from the sun.

The following theory is advanced, which to me seems a reasonable explanation of the manner in which the aurora is manifested:

The quantity of electricity in the atmosphere is not constant, but it is evident that it is capable of containing only a certain amount in an invisible state, and that upon becoming surcharged the surplus is, so to speak, condensed, and manifested as an optical phenomenon, — illustrated in a rough way by the change which takes place in atmospheric vapor, which is invisible until condensation occurs, — one type of which is the

aurora, the colors depending upon the rarity of the atmosphere, also upon its relative dryness. As moist air is a fairly good conductor, it is capable of holding a much larger quantity of electricity in an invisible state. It so happens that as the magnetic waves enter the lower atmosphere where the humidity is greater, the colors disappear; so that the aurora really extends to the surface of the ground, affecting the magnetic needle, but the visible portion ceases at that point where the moisture in the atmosphere is sufficient to conduct the electricity in an invisible state, which is from a few feet to an elevation of several miles.

According to this theory the elevation of the aurora should, as it does, depend upon the latitude of a place, for, as before stated, the intensity is greatest near the magnetic poles, and in that neighborhood it is possible for it to be visible in winter during a dry spell quite to the surface of the earth, whereas at a distance, the magnetic intensity being less, the elevation would be higher, until we reach the tropical zone, where auroras are unknown.

The principles of the concentration of the magnetic waves near the poles can be illustrated by the text-book illustration of a magnet and iron filings. Magnetic disturbances should be felt equally at both the north and south poles, and it is probable they are, the visibility of the electricity depending upon the moisture in the air, and as the southern hemisphere consists of so much more water than the northern, it is evident the humidity is greater, and that it extends to a higher altitude, thus allowing the magnetic waves to reach the earth oftener in an invisible state.

Mr. Wilde's theory * of a gaseous sphere rotating in the plane of the ecliptic with the earth may not be so far out of the way, provided we can imagine the frictionless zone separating the gaseous from the solid sphere to consist of ether, which, as far as we know, fills not only the interplanetary and interstellar spaces, but penetrates all solids, is elastic, has density, and is undoubtedly frictionless.

The diurnal variations of atmospheric electricity correlate very closely with the diurnal variations in atmospheric pressure;

* See article in American Meteorological Journal, January, 1892, by Prof. Frank Bigelow.

thus the true explanation of the two daily maxima and minima variations in pressure may be more closely connected with atmospheric electricity than has heretofore been suspected, and Newton's surmise that all phenomena may be explained through the influence of this subtle medium, which his great mind so correctly theorized, but which he was unable practically to demonstrate, may be a fact capable of scientific proof at no distant day.

BUFFALO, N. Y., June 22, 1892.

WARM AND COLD SEASONS.

H. GAWTHROP.

IN the April number of this JOURNAL attention was called to what appeared to be method in the result of grouping the monthly mean temperatures for the winter season at Philadelphia, for twenty years. The article was published to invite discussion, and comment has been made upon it by Prof. Hazen in the July number. His conclusion that there are no sequences in temperature conditions, for so long a period as the result of the grouping would indicate, seems to be proved by his illustration, but there is further evidence to be given in the affirmative.

That the question may be put to a close test, selection is made of San Diego, Cal., as a point at which there is a narrow range of temperature. In the table below, the monthly mean temperatures, from the records of the U. S. Weather Bureau, for the six coldest months of the year, November to April inclusive, have been arranged in order, from the highest average to the lowest, for twenty-one years, and placed in three groups of seven each.

MONTHLY MEAN TEMPERATURES, SAN DIEGO, CAL.

	Nov.	Dec.	Jan.	Feb.	March	April	6 Mos.
1888–9	59.9	58.2	54.8	58.0	59.2	60.4	58.4
1876–7	59.4	56.8	57.4	57.9	58.9	58.3	58.1
1890–1	63.8	60.8	54.6	53.3	56.9	58.2	57.9
1877–8	60.6	56.8	55.6	56.0	56.7	58.1	57.3
1884–5	58.6	54.4	54.0	55.4	59.6	62.0	57.3
1885–6	59.6	57.1	55.9	58.5	55.0	57.2	57.2
1883–4	58.7	57.5	55.0	55.9	56.5	57.6	56.9
Averages 7 years .	60.1	57.4	55.3	56.4	57.5	58.8	57.6

MONTHLY MEAN TEMPERATURES, SAN DIEGO, CAL.—*Continued.*

	Nov.	Dec.	Jan.	Feb.	March	April	6 Mos.
1889–90	62.0	57.4	51.0	54.3	56.4	58.6	56.6
1872–3	59.4	55.4	56.7	53.3	56.7	58.0	56.6
1875–6	60.3	56.9	51.9	55.9	54.9	59.0	56.5
1887–8	59.2	54.6	51.6	54.9	55.8	60.8	56.2
1880–1	56.2	56.9	52.8	55.7	54.3	60.8	56.1
1871–2	58.3	56.8	52.7	55.2	56.4	56.0	55.9
1891–2	59.4	52.2	55.1	55.0	56.0	57.8	55.9
Averages 7 years .	59.3	55.7	53.1	54.9	55.8	58.7	56.3
1886–7	56.0	56.0	54.3	52.9	57.2	59.0	55.9
1882–3	57.0	55.7	53.4	53.9	57.4	57.4	55.8
1878–9	57.5	53.5	52.3	54.8	57.9	58.1	55.7
1873–4	60.3	54.3	54.7	52.6	52.6	56.2	55.1
1874–5	56.7	53.3	53.4	54.6	55.0	57.8	55.1
1881–2	56.8	55.0	50.4	51.2	55.1	56.6	54.2
1879–80	56.2	53.9	52.5	50.8	52.1	56.5	53.7
Averages 7 years .	57.2	54.5	53.0	53.0	55.3	57.4	55.1

It will be seen that the average of each group bears a symmetrical relation to the other groups. The volume of temperature, if such an expression may be used, seems to be uniformly distributed throughout the season. If each year is examined alone there is, apparently, no such sequence between the earlier and later months, as shown by the averages, but commencing at the top and comparing each year with the bottom or coldest season, we find that the temperature for each month in the warm season is greater than that of the corresponding month in the cold season, until we reach the eighth line. Then again, commencing at the bottom and comparing in like manner with the top or warmest season we reach the eighth line, in going up, before we find reversal of the order. Each one of the seasons comprising the outer groups appears to have been cast in a different channel throughout from that of the extreme season.

A more striking and perhaps more conclusive showing is made by placing twenty seasons (leaving out last winter) in two groups of ten each. The averages and extremes of each group are shown below, and in the same table are placed the averages and extremes of August, September, and October of the years preceding; and of May, June, and July of the years succeeding, the winter months.

MONTHLY MEAN TEMPERATURES, SAN DIEGO, CAL.

Ten Warm Seasons.

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	6 mo.	May	June	July
Highest	71.8	70.2	67.2	63.8	60.8	57.4	58.5	59.6	62.0	58.4	63.3	66.3	69.0
Average	69.7	68.0	64.0	60.2	57.1	54.7	55.9	57.1	58.7	57.3	61.0	64.2	67.9
Lowest	68.4	65.1	61.3	58.6	54.4	51.0	53.3	54.9	57.2	56.5	60.0	62.7	66.8

Ten Cold Seasons.

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	6 mo.	May	June	July
Highest	72.1	68.3	66.2	60.3	56.9	54.7	55.7	57.9	60.8	56.2	62.6	66.0	68.7
Average	68.7	66.5	62.7	57.4	55.0	52.8	53.7	55.4	57.9	55.4	61.2	64.5	67.0
Lowest	65.8	63.1	59.7	56.0	53.3	50.4	50.8	52.1	56.0	53.7	60.1	63.0	63.4

It will hardly be claimed that there is no "method" in the result. The "highest" temperatures of the warm group are greater than those of the colder group for eleven consecutive months, and the "average" and "lowest" of the warm group are greater than in the colder group for nine consecutive months.

The parallelism to which attention has been called comes from the persistence of temperature in one direction for considerable periods. To illustrate this we will take the monthly mean temperatures of San Diego and arrange the excesses and deficiencies on each side of a line representing the normal as follows: —

	EXCESSES.	DEFICIENCIES.
Aug., 1871	+ 2.9	
Sept., "	+ 1.1	
Oct., "	+ 2.2	
Nov., "	— .6	
Dec., "	+ .9	
Jan., 1872		— 1.1
Feb., "	+ .4	
March, "	+ .2	
April, "		— 2.3
May, "		— .7
June, "		+ .5
July, "		— .8
Aug., "		— .3
Sept., "		— 1.2
	&c.	&c.

To save space the operation is not continued here, for the result can be stated more briefly. It will be noticed that some of the changes for one month are entered as in the general course,

and this must be explained. The effect of taking monthly means is to eliminate the transient changes of temperature, but this is not always complete, for phenomenal extremes may affect the relation of one mean to that of the next, even to reversal of the seasonal order. In the two hundred and forty months of the twenty years we are considering, there were thirty-two changes of one month each. Of these, nine reversed the usual order, as for instance making February colder than January, and many were of slight divergence from the normal. From a study of them by averaging three months together it seems clear that but seven of the thirty-two should be considered as indicating a change of course. If the track of the temperature is likened to that of a vessel sailing close to the wind, the other twenty-five are but temporary luffs in the otherwise general course.

At the start in August, 1871, the course was in the direction of excesses until December, and continued, except for January, until March, 1872, when it changed to deficiencies. This course continued for thirty months until September, 1874, when there was a change for one month, and back again until April, 1875. There were then three courses in the fifteen months until July, 1876, when a change to deficiencies for two months occurred, followed by excesses for twenty months until May, 1878 ; then a change to a course of nine months until February, 1879, when, after a change of one month, there followed a stretch of twenty months, without even a "luff", until November, 1880. The alternations continued in this way throughout the twenty years, there being forty-four courses in all, ranging from one month to thirty months.

When stated portions of the twenty years are selected and averaged in groups of warm and cold, as in the table, the temperatures are part of these parallel courses and it follows that the averages are parallel to each other.

The changes from one course to another, which happen at any season, and the one month exceptions we have noted, are responsible for the lack of sequence in the months of the individual years.

The problem as to what causes these irregular and persistent courses in the temperature may involve in its solution the possibility of forecasting the general character of a season's temperature.

THE FACTS ABOUT RAIN-MAKING.*

GEORGE E. CURTIS.

ALTHOUGH for all practical purposes the experiments at Midland were a failure, we may recognize a single result of scientific interest that seemed to be fairly well attested. In several instances, when a dense threatening cloud was overhead, a sharp detonating explosion was followed after an interval of twenty or thirty seconds by a spatter of rain, or, if it was already sprinkling, the blast was followed by a very noticeable momentary increase of the drops. This result occurred a sufficient number of times to indicate that the phenomenon was a real effect of the explosions. The importance of the observation lies in its bearing on the cause of the similar phenomena frequently noticed during thunderstorms, when a clap of thunder is followed by a shower of large drops of rain. Whether these drops are aggregated mechanically by the air waves set in motion by the concussion, or whether, on the other hand, it is a rapid condensation that produces at the same time both the large rain-drops and the electric charge, has been much discussed ; but the weight of opinion is in favor of the latter view.

This interesting result (if such it prove to be, for it is not yet conclusively established) is not, however, what the experiments were designed to accomplish, which was to produce rain in measurable quantity and whenever needed, so as essentially to transform the conditions of habitation of the semi-arid plains, and thus largely to increase the value of these lands. The appropriation has been expended, but the hoped-for modification of climate is no nearer realization than before, and no indication has been obtained that there is any possibility of accomplishing it. But the mere waste of nine thousand dollars would be of small consequence if the effect of the enterprise could be confined to the coffers of the Treasury. A very serious phase of the matter is the secondary effect of the experiments on the public mind, and the resulting attitude of the people towards fruitful meteorological investigation.

* Extract from the *Engineering Magazine*, July, 1892.

In the first place, the simple fact of the conduct of such experiments by the Government invests the attempt with an importance which it could not otherwise obtain. A private individual may engage in some impracticable scheme, without seeking the counsel or even against the advice of competent specialists, and no attention will be paid to it. But if the Government engage in the same undertaking it is immediately assumed to be a rational project. This is necessarily the case, for the public at large have no means of distinguishing one project from another. Thus, in the present instance, people in general had little knowledge that the appropriation was made by Congress principally at the instance of a single member, without the recommendation or endorsement of the scientific staff of the Department of Agriculture, or of any reputable physicist in the United States. Accordingly, the undertaking was assumed by the great body of the people to be one of the lines of investigation taken up by the Department of Agriculture, and so the responsibility for it was thrown alike upon the Government and upon science. The efforts of the Government are accredited because they are believed to be the outcome of the best scientific thought of the day.

This confidence of the people in the scientific work of the Government is a gratifying tribute to the labors of our scientists and an unconscious testimonial of which they have reason to be proud. But the greater the confidence which is reposed, the greater is the responsibility not to abuse it. Both wisdom and economy suggest that Congress should hear the opinions of competent specialists before engaging in doubtful scientific projects. Likewise, there rests upon every scientist in official position the responsibility of not advising any investigation which will not bear the closest scrutiny.

While travelling through the Southwest last summer my first observation and my last was the profound interest felt by all the people of that region in the outcome of the rain-making experiments. A feeling of expectancy pervaded the entire region from St. Louis to El Paso,—a readiness to believe in the possibility of accomplishing almost any result that the expedition might attempt, however chimerical or impracticable it might at other times have seemed. This was not credulity, it was faith,—faith in the Government, faith in science, and faith in the hon-

esty and sincerity of the Government's agents. I then began to see how seriously the confidence of the people had been abused even in the organization of an expedition to make rain by concussions, for meteorologists have declared unanimously that the idea is not supported either by rational theory or observational data. Viewed historically, the idea that noises and concussions will produce rain is found to be a part of the folklore of very many primitive peoples, and to revive it now is to reject the light of civilization and to retrograde to a cruder and less rational apprehension of natural phenomena.

Nor was the impression thus awakened either corrected or compensated by the subsequent methods employed. The effect of the undertaking became widespread and irreparable through the sensational accounts which were telegraphed to the press and published in every village in the land. When I arrived at Midland, on Aug. 10, I found there an employee of the expedition, who had come in from the ranch where the experiments were conducted to send a first telegraphic announcement to the country. The occurrences upon which this telegram was based have already been described. On the preceding evening, Aug. 9, two or three shots of rackarock had been fired, not as an experiment to produce rain, but simply as a test of material, and no result was expected; but the next afternoon, when considerable rain fell, the *post hoc* and the *propter hoc* were identified and the following message was hurriedly sent: —

"*The Hon. C. B. Farwell,* Chicago: Preliminary. Fired some explosives yesterday afternoon. Raining hard to-day."

The first telegraphic report was followed at intervals by others which were sent throughout the country and were cabled abroad. As the actual operations and results have become known, the attitude of the newspapers very generally has changed from unsuspecting and ready acceptance to satire and ridicule. But the widespread belief in the first announcements of success cannot easily be corrected. Where millions saw the despatches, only hundreds have read a detailed account of the exact facts, and a vast number of people still believe that the experiments were in some degree successful, and that noises and concussions, when made for the purpose, will produce rain.

So error which will require years of teaching to eradicate has been sown broadcast in a single summer, and the rain-making myth is added to the numerous errors about the weather which already prevail.

Charlatans and sharpers have not been slow to seize the opportunity thus afforded. Artificial rain companies have sprung up and are now busily engaged in defrauding the farmers of the semi-arid States by contracting to produce rain and by selling "rights" to use their various methods. In South Dakota public meetings in their interest have been held and the subject has become one of the vital questions of the day.

Those who have read the later detailed accounts of the operations, as well as the telegraphic despatches, have in general suspended judgment upon the question. In the midst of conflicting statements they do not know what to believe, and the only thing clearly apprehended is that their confidence was misplaced. This may prove to be a blow to scientific meteorology even more serious than the dissemination of error. Of all the sciences, the results obtained by meteorology contain least that is dramatic or spectacular. It is built up of generalizations and inductions based upon years of faithful prosaic observation, and this must continue to be its province. But these experiments have easily captivated the popular mind and aroused a cry for their continuation, in consequence of which it will be more difficult than ever to interest the people in the very commonplace methods of meteorological investigation.

This aftermath of the rain-making experiments, although unforeseen, serves as an excellent warning. For the honor and good name of the Government and of science, it would be well if we had seen the last appropriation to produce rain by bombarding the heavens, and the last expedition which should mislead the people by sending out premature and sensational reports.

CONVECTIONAL WHIRLS.

PROF. H. A. HAZEN.

IN this JOURNAL for May at page 19, there is a short statement regarding the conditions promoting the unstable equilibrium needed for the formation and development of storms, that ought

not to pass unnoticed. Prof. Davis seems to follow Dr. Hann in thinking that storms in our latitudes are "due to eddies driven by the general circulation of the atmosphere, and not to spontaneous convectional action." The simplest argument in favor of this view is the increase in number and intensity of winter storms. "If they were of convectional origin, they should be most frequent in summer, like the undoubtedly convectional thunderstorms. In winter the vertical decrease of temperature is generally slow, thus weakening the opportunity for convection, and the retardation of cooling in ascending currents by the liberation of latent heat is much less effective at the low temperature of winter, than at the high temperature of summer."

These views are unique coming from an avowed adherent of this theory; they deserve careful attention from all supporters of the convection theory. It is possible that one or two points have been overlooked in this attack, and these should be met by those inclining to the new theory. Dr. Hann has adopted the view, so strongly maintained by M. Faye for many years, that our storms are eddies in the general flow of the air in the upper regions from the equator to the poles, but he does not tell us what originates this eddy; and that is a most important consideration. Moreover, nearly all our storms are not in this poleward current, but move in a somewhat curving path from west to east.

Again, it is difficult, if not impossible, to see how such an eddy could communicate its action downward through a frictionless medium; but even if such an action could take place, by the ordinary theory the air would be dried, and no rain could possibly occur. Lastly, it has been proved by Prof. Loomis and others that there are no whirls at all above four thousand feet.

As to winter storms: when this same objection, as regards the lack of an unstable equilibrium in winter, was made some years since, it was met by a very good authority by the suggestion that the steep temperature gradient from south to north would account for the abundance and intensity of winter storms. Is it certain that there is not a strong tendency to an unstable condition in the atmosphere in winter? It has been shown that the diminution of temperature with height at Mt. Washington is fourteen degrees in winter and twenty degrees in summer; and at Pike's Peak it is twenty-four degrees and thirty-seven

degrees at these seasons. Is not this exactly the condition described by Prof. Ferrel, "Recent Advances, etc.," page 51? "It is well known that if any portion of the air, or of any liquid, or a solid body immersed in a liquid, has a density less than that of the surrounding parts at the same level, it tends to rise up, and, if not hindered, it continues to rise as long as its density is less than that of the medium surrounding it, until it comes to the top." I have made diligent search for just what the diminution of temperature with height should be to produce an instability in the atmosphere, but have not learned it. It is certain that a diminution of one degree, Fahrenheit, in one hundred and eighty-six feet, would be the most stable condition possible, and this should be frequent in winter. Now we have seen that the diminution at Mt. Washington, on the average, is one degree in four hundred and fifty feet, and at Pike's Peak it is one degree in five hundred and eighty-nine feet in winter, and it seems plain that on the passage of storms it must be much less than that, so that we have this instability very marked; but in summer the diminution is only one degree in three hundred and fifteen and three hundred and eighty-two feet at the two stations, respectively, and, in addition to this, the change in temperature on the approach of a storm in summer is vastly less than in winter. It seems well proven that the conditions of instability on the convection theory are far greater in winter than in summer. We should not forget that Prof. Ferrel in another part of his book alludes to the particular and very different instability in summer in which the diminution of temperature with height is enormously increased, thus bringing about a condition which Prof. Davis has described as heated air struggling to escape through a "cold cover," or words to that effect.

The most remarkable view advanced by Prof. Davis, however, is that mountain observations, according to Dr. Hann, show that the air in the centre of our storms is, as a mass, colder than in our high areas. That air in a storm is abnormally heated to great heights is a fundamental doctrine of meteorology. There is hardly a fact in observational meteorology so well established as this. There does not seem to be so conclusive a point in the whole range of theoretical discussions as to atmospheric movements as this, that the air in a storm must be heated and in a

high area must be cooled. Moreover, it has been shown that Dr. Hann has been misled in studying the distribution of pressure and temperature at mountain stations, for the temperature change is far in advance of the pressure change, so that, while the temperature changes at base and summit are exactly coincident, the pressure change lags behind at the summit. It seems as though this last point in Prof. Davis' argument is the most important of all, and demands from meteorologists the most searching inquiry.

JUNE 28, 1892.

CURRENT NOTES.

American Association of State Weather Services. — A convention of representatives of State Weather Services was held in Rochester, N. Y., on Aug. 15 and 16, 1892, in conjunction with the Forty-third Meeting of the American Association for the Advancement of Science. The convention was called to order by Prof. Mark W. Harrington, Chief of the Weather Bureau, who made an address of welcome to the representatives present. He suggested certain important subjects for discussion, and appointed committees on permanent organization, programme, etc.

A permanent organization was effected, and the following officers were elected: President, Major H. H. C. Dunwoody; First Vice-President, B. S. Pague, of Oregon; Second Vice-President, G. M. Chappel, of Iowa; Secretary, R. E. Kerkam, Chief of State Weather Service Division, Weather Bureau; and Treasurer, W. L. Moore, of Wisconsin.

The title, American Association of State Weather Services, was adopted by the Convention, and it was decided to hold annual conventions in future at the same time and place as those of the American Association for the Advancement of Science.

The following representatives were in attendance: The U. S. Department of Agriculture, Weather Bureau, being represented by Prof. Mark W. Harrington, Chief; Major H. H. C. Dunwoody, Forecast Official; Mr. R. E. Kerkam, Chief of State Weather Service Division; Mr. N. B. Conger, Inspector; and Mr. F. J. Randolph, Stenographer. F. H. Clarke, Arkansas; J. A. Barwick, California; John Craig, Illinois; C. F. R. Wappenhans, Indiana; G. M. Chappel, Iowa; Frank Burke, Kentucky; E. A. Evans, Michigan; G. A. Lovelend, Nebraska; J. Warren Smith, New England; E. W. McGann, New Jersey; R. M. Hardinge and W. O. Kerr, New York; C. M. Strong, Ohio; B. S. Pague, Oregon; H. L. Ball, Pennsylvania; S. W. Glenn, South Dakota; G. N. Salisbury, Utah; J. N. Ryker, Virginia; and W. L. Moore, Wisconsin.

Many of the representatives who were unable to be present at the convention forwarded papers giving their views on various subjects of interest to be discussed.

The subject of instrument-shelters and a uniform manner of their exposure was debated, and it was the concensus of opinion that a uniform pattern of shelter should be adopted for use throughout the entire country. The subject was referred to a committee consisting of Messrs. Smith, Moore, and Pague, with instructions to report as to the most suitable shelter and manner of exposure to be adopted generally by State weather services.

On the subject of whether the voluntary observers should be supplied with self-registering maximum and minimum thermometers, the prevailing

opinion was that such instruments should be issued, and used in determining temperature means and averages wherever and whenever practicable. The old method of making readings at the 7 A. M., 2 P. M., and 9 P. M. observations of the dry thermometer shall be continued whenever desired, but the means should be deduced from the self-registering thermometers where such instruments are in use.

As to the adoption of a form to cover the needs of a great majority of the voluntary observers who are supplied with dry or maximum and minimum thermometers and rain-gauge, it was decided to adopt a form which was suggested by the Secretary, so arranged as to admit of making three or four copies at one writing by means of the indelible carbon process, thus saving the observers the copying of the form at the end of the month ; the object of this arrangement being to give a copy of the monthly report to the office of the Chief of the Weather Bureau, one to the office of the director of the State service, and one to be retained by the observer, and also to make such additional copies as may be desired to furnish to the local press, etc.

The forecasting of thunderstorms was the fourth subject discussed, and an interesting paper on this topic was read by the Wisconsin representative.

The proposition to print the weekly, monthly, and annual reports of the State weather services in a uniform manner was freely discussed. The desirability of uniform reports was generally admitted, but it was thought impracticable at this time to take any action in the matter, as a number of States have appropriated funds for printing reports according to definite size and style.

The discussion of the question of the best methods of signalling weather forecasts by displaymen covered a wide range. The flag, the whistle, the semaphore, and the sphere, bomb, and flash-light systems were freely discussed, and an interesting paper was presented by the New England representative on the system of spherical bodies hoisted on a staff. This subject was referred to a committee composed of Messrs. Conger, Glenn, and Kerkam, for report at the earliest practicable date.

On the subject of inspection of voluntary observers' stations, the decision was that each voluntary station should be inspected at least once each year, to keep up the interest of the voluntary observers, and to enable the directors of State services to become thoroughly familiar with each station and its surroundings. It was recommended by the Association that sufficient leave of absence be granted the Weather Bureau representative at each State service centre to enable him to make a tour of inspection.

Relative to the subject, "The relation of State Weather Services to Agricultural Colleges and Experiment Stations," it was decided that, owing to the lack of telegraphic facilities and other means of disseminating weather information, it would not be practicable, generally, to have the central stations of the State Weather Services at such colleges or stations, but that a very close co-operation would be desirable.

The subject of an exhibit at the World's Fair was the last general subject discussed. It was decided that each State service should have its exhibit in the building set apart for the use of the State, and not to have the ex-

hibits collected in the building for the use of the United States Weather Bureau.

Mr. E. T. Turner, of New York, and Mr. E. H. Nimmo, of Michigan, were elected to active membership in the Association, and the following honorary members were also elected: E. F. Smith, California; Prof. R. Ellsworth Call, Iowa; Chas. C. Nauck, Arkansas; Prof. Wm. H. Niles, Massachusetts; G. H. Whitcher, New England; H. G. Reynolds, Michigan; H. F. Alciatore, Oregon; Major Richard V. Gaines, Virginia; Prof. A. L. McRae, Missouri; C. F. Schneider, Michigan; Prof. Louis McLouth, South Dakota; and all active voluntary observers of the United States Weather Bureau.

After adopting resolutions of thanks to the American Association for the Advancement of Science and others for courtesies extended, the meeting adjourned *sine die*. R. E. K.

The British Association at Edinburgh.—The following are abstracts of the principal papers relating to Meteorology which were presented to the British Association for the Advancement of Science at its Edinburgh meeting, Aug. 3 to 10, 1892, and of the discussions which followed them:—

Lord McLaren submitted to the Mathematical and Physical Section the report of the committee appointed for the purpose of co-operating with the Scottish Meteorological Society in making meteorological observations on Ben Nevis. The mean temperature of 1891 at Fort William was 47°, being 0.2° under the mean of previous years. On the other hand, the mean temperature at the top of the mountain was 31.3° or 0.3° above the average of the year. The mean temperature at the top as compared with the bottom of the mountain was half a degree relatively warmer. The lowest mean monthly temperature occurred at both observatories in March, the mean at the top being 20°, being the lowest monthly mean since the observatory was opened. The highest monthly mean at the top was 43.1° in June, and at Fort William 57.7°, also in June. The general character of the weather was anti-cyclonic, with, therefore, a large amount of sunshine, and for the time of the year, a small difference in the temperature at the two observatories. The rainfall for the year was 178.02 inches; in 1890 the amount was 198.34 inches. These were, by considerable amounts, the heaviest annual rainfalls yet observed. At Fort William the amount was 78.81 inches, or nearly 100.00 less than on the top of the mountain. The number of days on which the rainfall was *nil*, or less than the hundredth of an inch, was 106, there being only one fair day in August, but the unusually large number of nineteen fair days were reported in April and eighteen in June. Mr. R. C. Mossman had investigated the remarkable squall which occurred in the British Islands on Feb. 1, 1892. The more important of the results were the rapid rate, about forty miles an hour, with which it swept over the country from north-west to south-east; the sudden fall and equally rapid rise of pressure being at many places fully six hundredths of an inch; the sudden great fall of temperature, fully 10° at many places, and the sudden change of wind. These features were well marked in the Ben Nevis observations,

which showed well, among other points, the great height in the atmosphere the squall reached, bearing in its train totally changed conditions of temperature and moisture. Mr. Mossman had been engaged in discussing the remarkable series of observations made by Mr. Wragge, in 1882, at eight stations well distributed up the slopes of Ben Nevis from Fort William to the top. The work was so far advanced as to indicate the important bearing of the results as regards the vertical distribution of pressure, temperature, and moisture during the changes of weather of that year. On the suggestion of Mr. J. Y. Buchanan, a systematic series of observations had been instituted, having for their object a careful record of the height above sea level of the lower surface of clouds that from time to time covered the face of the mountain facing Fort William. The importance of these observations would be recognized when it was remembered that during a large portion of the year the observatory was enveloped with a completely saturated atmosphere. Steps had been taken to make the observation of dust particles in the atmosphere part of the regular work of the observatory. The observations already taken showed that dry thick fog contained a great amount of dust, but thin wet mist very little. It was when a thin dry mist enveloped the mountain that the lowest values were observed, and the all-important observation had been made, after consulting the daily weather maps of Europe, at the time when the winds differed in direction 90° or more from the winds then prevailing near the sea level. In other words, the drizzling and practically dustless winds blew out from a shallow cyclone, overspreading that part of Europe at the time. During the past year Mr. Omond had been engaged in an important inquiry into the relations of the Ben Nevis High and Low Level Observatories to the cyclones and anti-cyclones and the weather changes of the British Islands. Dr. Buchan was investigating the observations at the two observatories during February and September, 1891, in their relations to the changes of weather. Lord McLaren, having read the report, said that the work at Ben Nevis was being conducted in a very thorough manner, and the section would be satisfied that the grant which was made last year to the committee had been expended not merely in maintaining the ordinary work of the observatory but in developing that work on new lines and in endeavoring to obtain general results.

Mr. G. J. Symons gave in the report of the Committee on Underground Temperature. It dealt with observations taken at a boring made at a deep well in Wheeling, West Virginia. The well had been sunk by the Wheeling Development Company to a depth of four thousand five hundred feet. Observations had been taken last summer at depths of every one hundred and twenty-five feet to the bottom, and they had been carefully checked. The general result was this: taking the surface temperature at 51°, at a little more than one thousand feet from the surface the temperature was 68.75°; at three thousand feet the temperature was 87°; at four thousand feet it was 102°; and at the bottom of the well 110.15°. The increase of temperature became faster and faster towards the bottom. From one thousand five hundred and ninety feet to one thousand eight hundred and thirty-five feet the rate of increase was 1° in ninety-two feet; from one thousand eight hun-

dred and thirty-five feet to two thousand four hundred and eighty-six feet the increase was one degree in eighty-four and one half feet; the next group gave 1° in eighty feet, then 1° for sixty-two feet, and finally at the lowest depth 1° for fifty-eight feet. The mean of all these increases was 1° in seventy-two feet.

Mr. Symons submitted to the Geographical Section the report of the committee appointed to inquire into the climate of tropical Africa, whose re quest for observations has already appeared in this JOURNAL. Instructions for making observations in tropical countries have been prepared by the committee. The report stated that the work of the committee naturally fell into two branches; namely, first, the collecting and epitomizing of all available series of meteorological observations; and, secondly, the exercise of a friendly influence over existing, and the equipment of new, stations likely to promote a better knowledge of the climatological conditions of tropical Africa. As regarded the first of these objects the committee had prepared abstracts of the records of sixty-seven stations, including forty-two at which the observations extended over one year. As the places for which there exist records for at least one year number close upon eighty, the committee deemed it advisable to postpone the publication of these abstracts until it should be possible to present them in a collected form. Unpublished series of observations had been received by the committee from Capt. Chippendale (Upper Nile, 1874-5), Rev. C. Paul (Kipo Hill, 1881), Rev. Mr. Wakefield (Ribe, 1886-7), Rev. G. Smith (Assuan and Wadi Halfa, 1884-5), Rev. R. S. Hynde (Domasi, 1888-9), and Capt. Gallwey (Benim, 1891). The committee were likewise indebted for useful information and printed meteorological records to Capt. Capello, Prof. Neumayer, Dr. Tacchini, M. A. Angot, Dr. Etienne, and M. A. Lancaster.

Mr. H. N. Dickson, Edinburgh, gave a paper insisting on the need of teaching meteorology. He said the selection of subjects for elementary scientific instruction raised several questions concerning the relations of the different branches of physical science to each other. Apart from special applications to arts and manufactures, a want was felt of a subject which should at the same time afford opportunities of illustrating scientific methods and give examples of practical value in accounting for many natural phenomena of common observation. The ordinary phenomena of meteorology were already familiar to sailors, fishermen, and farmers, and, by properly classifying and arranging the facts already known to them, several laws might be made to suggest themselves. In this way the meteorological elements, which in this restricted sense underlie a great part of biology, geology, and geography, form an introduction to the fundamental notions of these sciences, as well as to those of physics involved in their discussion. There was as yet no instruction in meteorology available anywhere in this country, but in view of the rapid development of technical education it was urgent that this should be remedied. According to the last report of the Chief of the United States Weather Bureau there were twenty-seven institutions at which meteorology formed part of the regular instruction. In this way a demand for teaching in meteorology would be created, and the supply should come from some of

the main fixed centres of technical education, which should not only supply systematic instruction, but should be in a position to deal with questions referring to the relations of meteorology to agriculture, fisheries, etc., and to discuss the data collected by the teachers sent out bearing on local observations and prognostics.

WEATHER BUREAU NOTES.

Following the policy initiated by Prof. Harrington a few months ago, and recently referred to in the JOURNAL, the following gentlemen, local forecast officials, are at the Washington office, engaged on practice forecasts: George E. Hunt (New Orleans), Park Morrill (Atlanta, Ga.), Presley T. Jenkins (Cincinnati), and John B. Marbury (Nashville), replacing Messrs. Dey, Smith, Hammon, and Evans, who have returned to their respective stations.

Mr. E. B. Garriott, of the board of editors of the Monthly Weather Review, official forecaster for August, will be succeeded by Mr. R. E. Kerkam, who will make the forecasts for the month of September.

Some experimental work in connection with atmospheric electricity is being done at Blue Hill Observatory, by Mr. Alex. McAdie, of the scientific force.

Mr. A. L. Colton has resigned his position as private secretary to the Chief of the Weather Bureau, to accept a flattering tender of that of Assistant Astronomer and Secretary at the Lick Observatory.

Prof. Russell has returned from his trip in connection with river gauges and rivers, and will later submit a formal report on the results of his work.

The Bureau has taken up the "investigations on the relations of climate to organic life," as contemplated by the bill providing for the expenses of the Agricultural Department for the current year. To the immediate charge of this section Prof. Harrington has assigned Lieut. B. M. Purssell, an officer of the army, recently detailed for Weather Bureau duty, and who for many years was connected with the weather service, while it was controlled by the War Department.

Prof. Marvin has continued his experiments in new instruments, and the improved sunshine recorder, tipping-bucket rain-gauge and weighing rain and snow gauge, all electrically recording, are being perfected as rapidly as possible. It is hoped that some of these instruments may be purchased during the present year and given a careful trial at a few selected stations.

Librarian Fassig is absent in Europe. He will visit London, Paris, Berlin, and other places. Mr. Fassig hopes to make his trip of some practical benefit to the Weather Bureau, incidentally, in the way of looking up titles for the Bibliography of Meteorology.

In the Weather Bureau Bulletin No. 2, issued in July, Prof. F. H. Bigelow describes a "New method of dealing with observations of magnetic observatories, particularly such as use photographic traces for automatic records." Bulletin No. 3, just from the press, contains Prof. Hilgard's report on the "Relations of Soil to Climate." Prof. Whitney's paper,

"Some Physical Properties of Soils in their Relations to Moisture and Crop Distribution," is in press, and will shortly appear as Bulletin No. 4.

The following-named gentlemen, Weather Bureau observers, have recently been appointed local forecast officials: Bemer S. Pague, at Portland, Ore., Oscar D. Stewart, at Pittsburg, Pa., and B. H. Bronson, at Duluth, Minn. D. J. C.

August, 1892.

Recent Experiments in Artificial Rain. — In a letter to the Topeka *Daily Capital*, published on Aug. 3, Mr. H. R. Hilton, of Topeka, describes the conditions under which an "artificial rain" was recently produced in Morris County, Kansas. He spent most of the day (July 27) on which the rain-makers were at work about fourteen miles southwest of Council Grove, where the experiment was made, on a high prairie, where he could see any cloud formation over the place where the rain was to fall. During the forenoon white fleecy clouds floated in the air, the wind being southwest. About 2 P. M. the upper clouds came from the southeast, while at the ground the wind was a little west of south. At 4 P. M. the wind was southeast, and the clouds were increasing in number and size. About six o'clock the clouds began to join and formed one solid rain cloud, while rain began falling in different places. Mr. Hilton goes on to say: "The wind continuing to blow straight from the southeast . . . indicated to me that a low area storm of large diameter was approaching from the northwest. The changes of the winds from southwest to southeast confirmed this. The storm in Morris County was but an eddy in its southeast quadrant. . . . To confirm my theory I consulted the United States Signal Service maps on my return here to-day, and found on the 26th the lowest pressure central in the northwest; on the 27th at 8 P. M. this low area was central in western Nebraska, passing slightly to the north of us on the morning of the 28th. . . . Anyone familiar only in a general way with the meteorology of our western country could make such a contract as these rain-makers are reported to have made with the citizens of Morris County. . . . Undoubtedly these men keep themselves advised of the barometric changes reported several times daily by the United States signal stations, and they are thus enabled to calculate within a day or two when a 'low' will reach them, and they know that rainfall is an almost absolute surety to almost any place touched by these great circling storms, the diameter of which may vary from two hundred and fifty to one thousand miles, and the circumference take in several States in its embrace at once. If these rain-makers collected four hundred dollars from the citizens of Morris County for the rain of Wednesday evening, in my judgment they reaped where they did not sow, and Morris County people were paying for that which was given them by causes natural and not artificial."

*Thunderstorms of June in Wisconsin.**—During June, 1892, thunderstorms were reported 327 times, being heavy and unusually frequent. These

* Reprinted from the Wisconsin *Weather and Crop Journal*, August, 1892.

reports were received from 90 voluntary observers, quite equally distributed throughout the State. The month was an unusually wet one, the rainfall being about twice the normal amount.

The periods of greatest frequency were as follows: on the 6th, reports of storms were received from 76 stations; on the 7th, from 30; on the 13th, rom 42; on the 15th, from 37; and on the 16th, from 35. On each of these dates showers or thunderstorms were predicted in the forecasts sent out at A. M., generally for whole State, but in a few cases for only a part. The storms of the 6th and 15th occurred during the prevalence of southeast winds, caused by the approach of low pressure areas from the west; those of the 16th with the prevailing winds northeast and a low pressure approaching from the southwest; those of the 13th with southwest winds flowing into a low passing east over Lake Superior; and those of the 7th with east and northeast winds, the low pressure being central in the southwest part of the State. Of 260 reports the direction of storm movement was northeast in 99 cases, east in 52, southeast in 43, north in 25, northwest in 23, south in 11, southwest in 5, and west in 2.

Of 307 reports, 150 storms began between 12 noon and 6 P. M., 72 between 6 P. M. and midnight, 71 between 6 A. M. and noon, and 14 between midnight and 6 A. M.

Except in a few counties in the northwest part of the State, the temperature averaged a little below the normal for the whole month.

On eighteen days thunderstorms occurred either in a part or the whole of the State. No special thunderstorm warnings were sent, as the regular forecasts, telegraphed at 9 A. M. predicted storms in a part or all of the State on all but two of these dates, and in these two days only one shower was reported in one case and two in the other.

Observatory on Mont Blanc. — A second attempt is to be made to build an observatory at the top of Mont Blanc. As the workmen who tunnelled last year through the snow just below the summit did not come upon rock, M. Janssen has decided that the building shall be erected on the frozen snow. A wooden cabin was put up at the end of last summer, and in January and early in the spring it was found that no movement had occurred. According to the Lucerne correspondent of the *Times*, the observatory is to be a wooden building eight meters long and four meters wide, and consisting of two floors, each with two rooms. The lower floor, which is to be embedded in the snow, will be placed at the disposition of climbers and guides, and the upper floor reserved for the purposes of the observatory. The roof, which is to be almost flat, will be furnished with a balustrade running round it, together with a cupola for observations. The whole building will rest upon six powerful screw-jacks, so that the equilibrium may be restored if there be any displacement of the snow foundations. The building is now being made in Paris, and will shortly be brought in sections to Chamounix. The transport of the building from Chamounix to the summit of Mont Blanc and its erection there have been entrusted to the charge of two capable guides, Frederick Payot and Jules Bossonay.

Nature.

Proposed Forecasts of Bathing Conditions at Atlantic City, N. J.— The observer of the Weather Bureau at Atlantic City, N. J., Mr. W. T. Blythe, has, according to the Atlantic City *Daily Review*, begun a series of observations of the temperature of the sea water at that place. The record is made twice daily, at 9.45 A. M. and at 12.45 P. M., and the result of the morning observation is to be sent out to the hotels by telephone, in time to be of value to bathers. Mr. Blythe is of the opinion that such data from three or four years' observations will enable him to obtain the normal temperatures of the surf for each month throughout the year, and will establish a basis from which, in connection with the other data furnished by the Weather Bureau, he will be able to make very accurate forecasts of the bathing conditions twenty-four or forty-eight hours in advance. The temperature of the water in the morning is already being telegraphed by the railroads to their offices in Philadelphia, where it is posted on the bulletin boards.

Distribution of Weather Forecasts in New England.— The July Bulletin of the New England Weather Service contains some extracts from the Annual Report of Mr. J. Warren Smith, the director of that service. It appears that the daily weather forecasts are being sent at Government expense to ninety-three stations where flags are displayed or whistles blown; without expense to the Government by telegraph to eight places where flags are displayed or whistles blown ; by telephone to seven places; by mail to seventeen; by morning papers to six; while they are being sent to thirty-four stations of the Southern New England Telephone Company, and from there distributed to any persons connected with the company who ask for them; and to two hundred and twenty-nine places by railroad mail service. Many of the displaymen are sending the information to surrounding villages. The local and the morning forecasts are the ones most desired by the displaymen. Numerous letters from all parts of New England testify to the increasing interest taken in this work by the people, and to the value already derived from the dissemination of the forecasts.

PUBLICATIONS RECEIVED.

"Notes on a New Method for the Discussion of Magnetic Observations." By Frank H. Bigelow, Professor of Meteorology, United States Department of Agriculture, Weather Bureau. Bulletin No. 2. Published by authority of the Secretary of Agriculture, Washington, Weather Bureau, 1892. 8vo., forty pages.

"A Report on the Relations of Soil to Climate." By E. W. Hilgard, Professor of Agriculture and Agricultural Chemistry, University of California. United States Department of Agriculture, Weather Bureau. Bulletin No. 3. Published by authority of the Secretary of Agriculture, Washington, Weather Bureau, 1892. 8vo., fifty-nine pages.

"Extract No. 5 from Annual Report of the Chief Signal Officer, 1891. Report of Prof. T. Russell, in charge of the River and Flood Division." By authority of the Secretary of War, Signal Office, War Department, Washington, 1892. 8vo., one hundred and ninety-three pages.

"Pilot Chart of the North Atlantic Ocean." Hydrographic Office, Navy Department, Washington, Lieut.-Com. Richardson Clover, U. S. N., Hydrographer, August, 1892. This issue gives a chart of the hurricane of August 27-31, 1888, with a diagram of the intensified Trade-wind belt, which is a characteristic feature of almost every tropical cyclone.

"The American Journal of Science," New Haven. Vol. XLIV., No. 260. August, 1892.

"Astronomy and Astro-Physics," Northfield, Minn., August, 1892.

"Ciel et Terre," Brussels. Nos. 9 and 10, July 1 and 16, 1892.

"Das Wetter," Braunschweig. Heft 7, July, 1892.

"Meteorologische Zeitschrift," Wien. Heft 7, July, 1892.

"Report of the Kansas State Board of Agriculture," for the month ending June 30, 1892, containing a summary of the crops, notes of correspondents, list of district and county agricultural societies and fair associations, together with meteorology for April, May, and June, 1892. Topeka, 1892. 8vo., fifty-one pages, with charts.

"Report of the North Dakota Weather Service for the month of June, 1892, in Co-operation with the United States Department of Agriculture, Weather Bureau." Bismarck, W. H. Fallon, observer, Weather Bureau, director.

"Fourth Annual Report of the Experiment Station, Kansas State Agricultural College," Manhattan, Kansas, for the year 1891. Topeka, 1892, 8vo.

"Weather Crop Bulletin of the Tennessee Weather-Crop Service, in Co-operation with the United States Department of Agriculture, Weather Bureau." Nashville, J. B. Brown, acting observer and director.

"Michigan Crop Report of the Michigan State Weather Service, in Co-operation with the United States Department of Agriculture, Weather Bureau." No. 130, August, 1892. For this report returns were received from 667 correspondents, representing 525 townships.

"Monthly Review of the Colorado Weather Service, in Co-operation with the United States Department of Agriculture, Weather Bureau." Denver, W. S. Miller, observer, Weather Bureau, director, July, 1892.

"Bulletin of the New England Weather Service, in Co-operation with the United States Department of Agriculture, Weather Bureau." Boston, J. Warren Smith, observer, Weather Bureau, director. No. 5, July, 1892. This issue contains a communication from Alexander McAdie, M. A., of the Weather Bureau at Washington, with reference to the question whether auroras are seen on cloudy nights Mr. McAdie cites several instances from the Lady Franklin Bay Expedition where auroras were noted as being obscured by clouds. Some extracts are also given from the Annual Report of the Director of the New England Weather Service.

"Monthly Review of the Iowa Weather and Crop Service." Des Moines, Geo. M. Chappel, M. D., Local Forecast Official, assistant director. July, 1892.